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ABSTRACT

This paper deals with three areas: (1) the future job situation for people with doctoral degrees in the natural sciences; (2) the number of graduate students there should be in the natural sciences; and (3) some steps to improve graduate education in the natural sciences. In the Spring of 1970, persons with M.I.T. doctorates in physics and chemistry had fewer job choices than those with dotorates in the earth sciences, biology, or mathematics. Of the 3 job markets for doctorates in the natural sciences: industry, government, and higher education, only the latter is expected to grow significantly in the next several years, though the demand in the industrial sector may increase with an upsurge of the economy. The hiring rates in the higher education sector will, however, be a good deal lower than they have been. This means that Ph.D.'s are currently produced at a faster rate than they are needed, and this trend will probably have to be reversed. As for improving the quality of the graduate programs, students should be trained to: (1) contribute to the solution of society's problems, (2) take on broader responsibilities in industry, and (3) be effective teachers. (AF)

THE OUTLOOK FROM THE UNIVERSITY (THE NATURAL SCIENCES)*

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DR. ROBERT ALBERTY: Well, as an alumnus of The Council of Graduate Schools, it is a great pleasure for me to be back and have a chance to see so many old friends.

These are times which make us ask some very basic questions about doctoral education. How many persons with doctoral degrees are needed? What will they be doing during their lifetimes? How should the cost of their education be paid? Are there some students in our graduate schools who shouldn't be there, or who have been there too long? What is the best education we can give them?

I would like to spend my time on another set of three very difficult questions that I don't pretend to be able to answer, but I think we should be struggling with.

The first one is: What is the job situation

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going to be for people with doctoral degrees in the natural sciences?

The second one is: How many graduate students should there be in the natural sciences?

And the third: How can we improve graduate study in the natural sciences?

First, with respect to the job market, our experience at M.I.T. last spring was that the new Ph.Ds in physics and chemistry did not have the opportunity to select from very many competing offers, but they did get jobs.

The biologists and the biochemists, the earth scientists and the mathematicians, on the other hand, apparently did not really report any difficulty in finding jobs.

And I note within the fields of physics and chemistry there was a great deal of difference, depending upon the subfield and the type of activities these people were involved in.

However, we look forward to next spring with a good deal of apprehension.

The number of industrial interviewers who will be visiting our campus is down significantly, and we

are afraid that the hiring of new faculty that other institutions will be down as it will be at M.I.T.

Thinking about the job market in the natural sciences, there are three main sectors which I think we have to keep in mind; the industrial, the Federal, and the higher education sectors. Ted Cairns has told us about the outlook from industry and I cannot really add to that. I would simply like to emphasize that we must be careful not to confuse short-term cycling of the economy with long-term needs of the country.

Unfortunately, the time cycle for producing doctorates is sufficiently long so that it is difficult to adjust doctoral production for these short-term fluctuations.

In looking at the longer-term needs, I can't help but think that in providing for a growing population with the increasing problems with pollution, delivery of adequate medical care, exhaustion of natural resources, and still an increasing demand for a higher average standard of living require well-trained scientists and engineers in industry.

Although the Federal Government does not employ a very large fraction of Ph.Ds in the natural

sciences, as Charlie Falk's slides show, still Federal and R and D programs do support many Ph.D. scientists through both universities and industry. Thus, job opportunities for Ph.Ds in science are going to be greatly affected by Federal support of R and D in the amount of "R" in that R and D.

So far, most reductions in Federal funding have been due to inflation but the cumulative effect, as you all know, has been very serious and I am afraid that at the present time we are in the midst of a leveling off of the number of active research scientists, and if the present trends continue, that there will be an actual diminishment of the number of active research scientists in this country.

It is only when we come to the higher education sector that we can see an area that will probably grow at a significant rate in the next several years.

I would like to mention several indications of the future rate of growth for the higher education sector.

Perhaps you noticed as I did that the U.S. Office of Education has just finished counting the

degree credit enrollment in United States universities this fall and they find it is 8.55 million students, which is an increase of about 7.2 percent over last year. This is actually a faster rate of growth than the Office of Education is projecting in its projections which are in press.

The Office of Education projections in press indicate the degree credit enrollment in American universities and colleges will increase about 4.3 percent per year for the next several years with the two-year colleges growing at a faster rate, 5.7 percent per year, and the four-year colleges at a rate of 3.6 percent per year.

I might also refer to the N.S.F. study which was just released a few weeks ago which showed the increase in science faculties between '69 and '70 which showed that there was a growth of 4.5 percent in the chemistry faculties, 2.5 percent in physics faculties, and 3.0 percent in mathematics, and 5.5 percent in biochemistry.

But what about the future? I think higher education will continue to need more Ph.Ds in the sciences, but the hiring rates will be a good deal lower than they

have been.

Now, what about the number of graduate students that there should be in the natural sciences? Various data and calculations indicate that we are currently producing Ph.Ds at a faster rate than they are needed, assuming that they receive a certain type of training and assuming that they are fitted only for a certain type of job.

One way to see how serious this problem may be is to divide the annual Ph.D. production, as reported by the National Research Council, by the number of Ph.Ds in 1968, as reported by the National Registry of Scientific and Technical Personnel. Although these latter numbers are not complete, they perhaps represent 80 to 90 percent of the working doctorates in the country and so I think they are probably good enough for this purpose.

In chemistry the doctoral production is 6.7 percent per year on this basis; in the earth sciences, 9.2 percent; in physics, 10.1 percent; in mathematics, 15.4 percent; in biological sciences, 20.4 percent.

Now, even allowing for retirements, transfers into other fields and the development of--really, these figures cannot continue indefinitely in the future

without growing opportunities for people with this training.

Now, there are four alternative courses of action. One is to reduce the Ph.D. production in science. Another is to change the nature of the training. And a third is for them to seek different types of jobs than they have in the past. Actually, I do not see any one of these as "the" solution to current problems, but I see some features of each of these possible solutions being followed simultaneously.

First of all, the Ph.D. production in science in the country is being reduced. At M.I.T. the enrollment in the graduate school and the School of Science is down eight percent from last year and the number of entering graduate students is down a good deal from that.

It would be nice actually if we had data for the country as a whole, but I am not aware of the kind of data we really need to understand current rates.

I am one of those who believe the country is going to continue to need Ph.Ds out of the present mold; that is, men and women who have experience in the advancement of science at the frontier and who want to

pursue this activity and to train students at a very advanced level.

In my view, the opportunities for advancing basic science are greater than ever and I think there will be major discoveries of tremendous importance to our society during the foreseeable future.

For this reason, I am really unhappy with reduction in Federal fellowship programs which have been permitting our very best students to develop, to design their own course of action and to pursue what they think would be the most promising careers for them in the future. And I think Wayne Reitz' graphs which showed that there has been a 40 or 50 percent reduction in these Federal programs is very bad for these stronger students.

Now we come to my final question: How can we improve graduate study in the natural sciences? In contrast with the first two questions, I think this is something which the graduate deans and their faculties can do something about. I know that graduate deans have been talking about new types of doctoral programs and I think some new ones are needed, but I would like to emphasize that I do not think we are actually using the flexibility which is inherent in many of our current

programs.

I note that the Economic Concerns Committee of the American Physical Society has just prepared a report in which they say, "We should counsel graduate students toward a well-grounded training in fundamentals, carried through with the broadest attitudes and wisest divisions." And in their report, John Gardner in his book "Excellence" of, I think, about ten years ago saying:

> "Nothing contributes more damagingly to the unemployment of educated talent than rigid specialization and rigid attitudes supporting this specialization. The future is necessarily hazardous for the individual who trains himself to do a specific job, receives an advanced degree for that line of work, and believes that society owes him a living for doing it."

I think in quoting John Gardner here, I am repeating things that other members of the panel are also saying, but I think it is of very great importance.

I think, in other words, that we need to train students as we have been doing, for exploration of science at the frontiers; we need to train students with

an interest in contributing to society's problems and to taking on broader responsibilities in industry; we need to train students who will take increased interest in teaching, and I think that in the science area especially perhaps, we need to be much more concerned with the job of teaching science to the non-scientists than we have in the immediate past.

In conclusion, I think this is the time for us to reexamine our programs, to identify their basic strengths and correct their weaknesses, and I hope that five years from now we will be able to look back and say this was a period that brought about major improvements in graduate programs.